The invention refers to a method for emission reduction with the cold start of engines by admixtures of hydrogen, whereby the hydrogen in the warmed up state of the engine generated will and subsequent latched becomes, and whereby the stored hydrogen becomes if necessary the engine supplied. Besides the invention refers to an associated apparatus for the execution of the invention process.

With the cold start of internal combustion engines catalytic measures for the emission control do not seize yet, because catalytic converters have neither for the pollutant dismantling the required temperatures nor particularly for NOx storage the required temperatures. In order to repair this problem, heating catalysts are known. These have however an high power demand, z. B. typically 3 KW.

Further is known that above all the NOx emissions of internal combustion engines without losses in the thermal efficiency permit thereby to become to be able that it with hydrocarbon hydrogen mixtures operated to become, the one lean combustion to reduced the far beyond region possible with hydrocarbons (Y. Jamal, M. L. Wyszynski, Int. J. Hydraulic gene Energy of volume. 19, No. 7, pp. 557572 (1994)). Thereby even substantial increases of the thermal efficiency measured became partial. For the continuous operation the hydrogen production became examined by reformation of hydrocarbons.

The operation of the endothermic catalytic steam reforming the use of the waste heat of exhaust gases becomes proposed with (JP 80-91803 A1) in latter connection, which leads to an additional increase of the efficiency in relation to exothermic reformation processes like the partial oxidation of hydrocarbons with air.

Instead of the catalytic already the plasma reformation of hydrocarbon for the hydrogen production became on board proposed motor vehicles (D. R. Cohn, A. Rabinovich, C. H. Titus, L. Bromine mountain, “Near term of possibilities for extremely low emission of vehicles using onboard plasmatron generation OF hydraulictowards”, international journal OF hydraulic gene Energy (1997) volume. 22, No. 7, p. 715-23). Here however as with the heating catalyst the problem exists that several KW of electrical power provided to become to have, which becomes generated in motor vehicles with small efficiency. In addition the electrical power supply requires expensive power electronics to the operation of the plasma.

Alternate one in addition became proposed with the GB 22 58 012 A to produce hydrogen for the operation of an engine by the response of water with metals. This response is to become from safety and cost reasons with such metals performed, which react only with elevated temperature with water. Thus warm one must become provided for the start of the response, which can become the engine the exhaust gas removed however during operation. Adverse one is that the vehicle additional with metal and water instead of commercial fuel supplied and the metal oxide disposed

resultant with the response to become to have. But the ansatzweise infrastructure does not even exist.

The pollutant emission can in principle be reduced thus with the cold start of motor vehicles by hydrogen admixture to the fuel. Here however the problem exists that to the required time because of the thermal inertia of catalytic reformers no hydrogen stands for order. The plasma reformation with thermal plasmas would have a sufficient short response time, has however like an already mentioned unfavourable efficiency and required for the cold start an additional memory for electrical energy. Also the hydrogen production by oxidation of metals with water would have the problem thermal inertia.

Object of the invention is it in contrast to this to suggest a method and to create an associated apparatus, possible with which in simple manner the temporary operation of an internal combustion engine with hydrogen admixtures is to the fuel and in particular the described above disadvantages are avoided.

The object is according to invention dissolved by the fact that with a method that becomes initially mentioned type fuel the bottom addition of water hydrogen reformed and is available in a pressure vessel. The Reformat before supply becomes preferably the pressure vessel catalytic purified, so that pure hydrogen becomes stored.

The invention is the basis the finding that for the hydrogen admixture in the cold start - under the small required amounts typically 40 liters/minute with normal pressure - not compellingly required is that the hydrogen becomes also direct generated in the cold weather starting phase. Rather will to the solve the problem proposed to produce and store in the required amounts bottom pressure hydrogen in the warmed up state of the engine over a longer period of time with small rats. The need is void to use for the hydrogen production a rapid method with small thermal inertia the z. B. a Plasmareformer would represent. This possibility became also recognized in the already mentioned GB 22 58 012 A, why the expensive combination of the hydrogen production from a metal water response and a metallic hydrogen reservoir for the start becomes provided there. Opposite this state of the art the required invention a significant smaller additional expenditure, in particular for existing systems.

An apparatus for the execution of the invention process is by a catalytic working reformer to the generation of the hydrogen stored of hydrogen from fuel and oxidizer, a pressure vessel as buffers for the hydrogen and characterized by Mittei for the supply to the engine. With this apparatus the hydrogen in the warmed up operating condition of the engine and thus sufficient exhaust gas temperature becomes by reformation of an hydrocarbon used as fuel generated, bottom pressure stored and in each case in the starting phase the engine supplied.

In order to reach with the invention for storage required pressure without additional effort at compression work, becomes for the hydrogen production the catalytic steam reforming of fuel with overpressure proposed. The overpressure in the reactor can be maintained thereby constructed and that waters and fuel with high pressure become evaporated only into the reactor injected and by supply of warm ones, which is extracted from the exhaust gas of the internal combustion engine there. Therefore is this method favourable-proves with motor vehicles with direct engines more insertable, there there z. B. in so-called. Common Rail systems the fuel with printing up to 120 bar is already present.

For the application of the invention process and the use of the associated apparatus are necessary with suitable engine infrastructure only a branch of the motor injection system with controllable valve, an injector for fuel as well as a second high pressure dosing system for waters. Suitable engines can be re-tooled with a such module.

With the invention it is particularly favourable that the waste heat of the engine in continuous operation with high efficiency and without large technical and infrastructural effort used will, in order to lower the pollutant emissions in the starting phase and in continuous operation and to increase the simultaneous efficiency of the internal combustion engine. Basis for the fact is the finding that

a) electrical measures to the operation of a reformer a comparatively small efficiency have, since electrical energy cannot becoming generated on board a motor vehicle so far with higher effect degree than that of the engine,
b) thermal energy, which results otherwise as waste heat, in light storable chemical energy and simultaneous into an useful cloth reacted will can. The steam reforming is an endothermic process, whereby the generated hydrogen represents both an energy storage and a substance essential to the controller of the motor combustion process,
c) the thermal energy over the vaporization of liquids for the storage of substances in a form, D. h. Overpressure, used will can, those the rapid retrieval of the stored substance ensured.

Other details and advantages of the invention result from the subsequent description of figure of embodiments on the basis the drawing in connection with other claims. Schematic in each case show

Fig. 1 the structure of an engine with downstream catalytic reformer and associated means for the supply of the fuels to the engine as well as for the fabrication and supply of the hydrogen generated thereby,

Fig. 2 in detail the formation in Fig. 1 used catalytic reformer.

On the basis the figs a system becomes the reduction of the emissions of internal combustion engines in the cold start described. The emission reduction made in this system by temporary admixture of hydrogen, which becomes generated in a suitable reformer. Essential one is in present context that the Reformerprozess becomes by thermal energy of the engine exhaust gas effected and thus a steam reforming made.

Known masses is favourable it to let the steam reforming run off bottom water surplus in order to avoid soot formation. Beside hydrogen (H2) also carbon monoxide (CO) and carbon dioxide (CO2) become generated during the steam reforming of fuel. CO is toxic, CO2 and the excess water the hydrogen would dilute and thus the storage requirement would increase. With the state of the art already proposed diaphragm separation subsequent by one the reformation will win pure hydrogen (see. B. Emonts et al., J. Power SOURCEs of volume. 71, pp. 288-293 (1998)).

To the operation of a thermal working reformer temperatures of 300 DEG C to 400 DEG C are required. The warm ones required for reaching this temperature the exhaust gas, favourable- proves immediate at the discharge opening elbow union removed becomes. That still hydrogen and CO-haltige exhaust gas of the reformer will the subsequent engine to the combustion supplied and thus helps to increase the efficiency and to lower the emissions also in continuous operation, since to the one the hydrogen a lean operation of the engine allowed, on the other hand the remaining components of the Reformerabgases similar as an exhaust gas recirculation the spatial homogeneity of the combustion to promote.

In accordance with Fig. 1 essentially consists the system formed for latter purpose of an engine 13 with exhaust strand 21 and a coupled, catalytic working reformer 1 thermal thereby. In detail the Dampfreformer 1 feed lines are and up to 20 bar pressure resistant dosing systems 2 and 3 for fuel and water associated. Those bottom pressure standing liquid own course material will in the reformers 1 thermal applied and it becomes thus by vaporization the desired hydrogen generated. However the hydrogen in the mixture with other gases, in particular carbon monoxide, and surplus water is present. There is therefore means 4 to the gas cleanup on the basis ultradünnen palladium silver (PdAg) - of a diaphragm on a ceramic support to the separation of the hydrogen from the Reformat present. The separated hydrogen arrived over a pressure valve 5 into a pressure vessel 6 and becomes there stored. In the pressure vessel 6 then the hydrogen continuous, D stands. h. independent of its engine-operatingdependent generation, for the order. A valve 7 and a conduit 8 serve for the controllable transport of the Reformerabgases for the carburettor and/or. to the fuel injection of the internal combustion engine, D. h. Engine 13, which by the unit 11, 12 indicated is. A gas outlet from the pressure vessel 6 contains a controllable valve 9 and a conduit 10 for the transport of the hydrogen to the unit 11/12 and/or. direct to the engine 13.

There is first sensors 14 to 16, for example thermocouples, to the measurement of the exhaust gas

temperature in the region of the discharge opening elbow union, to the measurement of the temperatures of a not represented catalytic converter or an other mechanism for the exhaust subsequent treatment and to the measuring the temperature in the reformers 1 as well as second sensors 17 and 18, z. B. capacitive pressure sensors, to the pressure measurement in the reformer and in the pressure vessel provided. Further means 19 are 13 present for the detection of the operating condition “rotational speed” and/or “accelerotor pedal value” of the engine.

One mu - processor-based control 20 of the reformer 1 possible in response of the operating condition of the engine 13 and of the sensors the 14 to 18 detected operating conditions of the whole system over valves 2 and 3 the dosage of fuel and water, and over a valve 7 the gas outlet of the Reformerabgases and over a valve 9 the dosage of the hydrogen from the pressure vessel 6. In particular the metering valves 2, 3 and 7, 9 are thus part mu - of the processor-controlled system. “Rotational speed and “accelerotor pedal value can become”, which mark the operating condition of the engine, also other for example the fuel mass flow, derived and for the control used over stored family of characteristics from the data.

The reformer 1 becomes favourable-proves so performed that he the exhaust pipe 21 of the engine 13 enveloped. Thus the waste heat of the engine contained in the exhaust gas can become 13 optimum used. Measures to the enlargement of the contact surface to the purpose of improved heat transfer are known and in standard works, z. B. VDI Wärmeatlas, for the design of heat exchangers take. As soon as with the sensors 14 and the 16 detected temperatures exceeded the minimum value for a safe flow of the steam reforming and the diaphragm separation of the hydrogen, become on the basis mu - the processor-regulated dosing systems 2/20 and 3/20 the reformer 1 fuel and water supplied. It is to be however always considered that the minimum temperature for subsequent measures of the emission control is not fallen below. Therefore becomes the temperature in the range of the emission control with sensor 15 detected and an operation of the reformer 1 suppressed if the minimum temperature for the emission control is fallen below.

For the diaphragm separation of the hydrogen and its storage bottom pressure the reformer 1 with overpressure operated must become and be corresponding designed. Likewise the supply of the fuels with overpressure must take place. Therefore the made dosage naturally over a feed line, becomes constructed in which by suitable pumps an overpressure. There is systems known, with which pressures up to 120 bar of constructed to become to be able. The valves 2 and 3 become favourable-prove designed as high pressure injection valves, as they become also used with diesel engines.

Fig. the gas cleanup shows 2 in the detail. It is an annular gas cleanup unit 40 with a diaphragm 42 from palladium silver (PdAg) as inner wall present, which in Fig. 1 overall rewritten means 4 to the gas cleanup realize, whereby these diaphragms on a ceramic substrate applied known-measured are. The diaphragm 42 of the gas cleanup unit 40 knows favourable-proves common with the ceramic substrate as tubes performed to be, the one hollow cylindrical unit 10, those in Fig. 1 overall indicated reformer 1 realized, in the open area encloses. The reform purity 10 has entrances 42, 43 and an outlet 45, the gas cleanup unit 40 an outlet 47. In connection with in Fig. 1 by means of microcontroller 20 controllable valves 2, 3 and 7, 9 forms it the metering units for for fluids the initially and starting materials.

The circumferential PdAg diaphragm 42 separates thus each other concentric cover-sent regions of the reform purity 1 from these enclosing tubes 40 of the gas cleanup unit. Their clearance is 43 filled with catalytic material.

The working gas of the reform purity 10 flows slow by the clearance filled with catalytic material 43 between exhaust strand 21 and diaphragm 42 and becomes successive thereby in COx, D. h. CO and CO2, and hydrogen (H2) converted. The hydrogen becomes 42 separate over the diaphragm over the outlet 45 the accumulator 6 from Fig. 1 supplied and there to the targeted use with the cold start of the engine 13 stored. This procedure allowed so by displacement of the chemical equilibrium an high conversion with the reformation. The residual gases are led away over the outlet 47 and controlled into the system returned.

With on the basis the Fig. 1 and 2 exemplarily illustrated arrangement is thus a compact apparatus described, becomes meaningful used with which the waste heat of the engine. Equally the pollutant emissions lowered become, in particular also in the starting phase of the engine and the efficiency of the engine in continuous operation increased.

The novel apparatus can also already supplement incorporated engines as auxiliary module into vehicles. Thus the cold start of engines becomes greatly improved.